Micro-Electromechanical Sensors (MEMS) Inertial Navigation System (INS)

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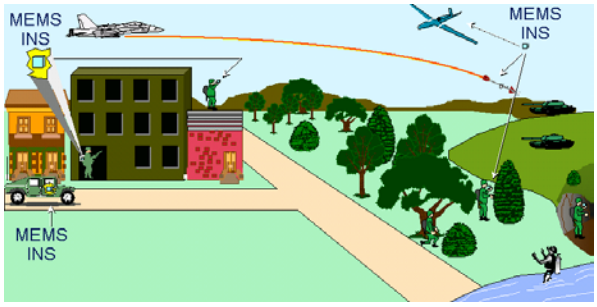
The MEMS INS program envisions a wide variety of applications. Many soldiers and vehicles will be equipped with GPS receivers. However, when those GPS receivers are inside buildings, under dense foliage or under water, the GPS signals are masked. When this happens, the MEMS INS can provide interim navigation until GPS signals are restored and help with re-acquiring GPS. It is also possible that the enemy will jam the GPS signals. Again, the MEMS INS can provide location information until GPS service is restored.

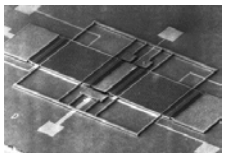
Being small and low cost, MEMS INS can support the guidance and navigation function in air-to-surface and surface-to-surface munitions. An INS also provides attitude with respect to local level and azimuth with respect to true north. Therefore, a MEMS INS can support pointing and orientation for artillery and targeting equipment.



There are three contractors developing IMU systems in the current phase 2 portion of the program. The contractors are Litton Guidance and Control Systems, Draper Laboratory and Kearfott Guidance and Navigation Corporation. The performance, power and volume goals are listed below.

1.0º to 10º/hr Gyro Drift Rate
<500 mg Accelerometer Bias
Temperature Range: -54 to 85ºC
Low Power <3 Watts
Small Size: <10 cu inch

The most difficult part of building a MEMS-based inertial measurement unit, or IMU, is the gyroscope. An IMU consists of accelerometers and gyroscopes. While MEMS accelerometers are relatively mature, MEMS gyroscopes are much harder to build, and have been the pacing technology in this program. The gyroscope designs developed by the three contractors in the program are depicted here. Starting from the left and going clockwise are the Kearfott Micro-Machined Vibrating Beam Multisensor (MVBM), the Litton SiGy™ and the Draper Laboratory TFG-12.

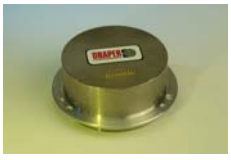


So how are they doing? Draper Laboratory will produce an IMU that meets the size and weight goals of the program. Kearfott's IMU will be a little larger, at 17 cubic inches. The use of ASICs in place of the discrete circuit boards would shrink the IMU to 10 cubic inches. Litton will be delivering a gyroscope only.

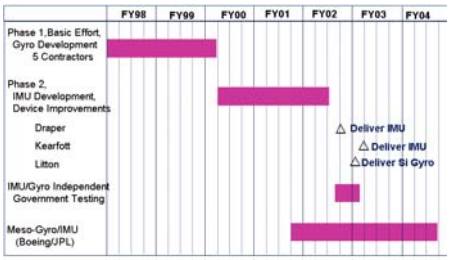
Kearfott IMU

The IMUs and gyro will be tested by the by the 746 Test Squadron at Holloman Air Force Base, New Mexico, starting with the Draper IMU. The units will be tested on rate tables and centrifuges under a variety of temperature and vibration conditions to see how well they meet the performance goals. When government lab testing is complete, the IMUs and

Draper IMU

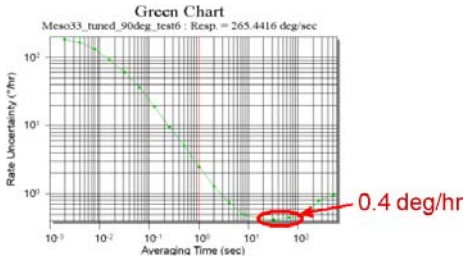


gyro will be available for testing by potential customers. If there is interest in test results, further testing or using them in an application, please contact Lt Col Gregory Vansuch.



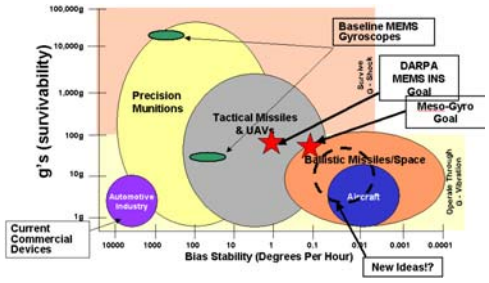
The MEMS INS program has shown that smaller, efficient MEMS-based IMUs can be produced. The performance, as measured by the gyroscope error, is expected to range from 1 degree/hour to 20 degrees/hour, depending on the environment. This accomplishment has laid the ground work for a number of other military programs interested in affordable IMUs.

As a variation on the MEMS theme, we started an effort one year ago to produce a meso-sized gyroscope, but using the same fabrication tools as the MEMS approach. The idea was originated at Boeing Space Systems and the Jet Propulsion Laboratory, and was initially sponsored by DARPA's Defense Science Office. The gyroscope is about 10 times the size of the MEMS gyros, but since the MEMS fabrication process errors are about the same, the expected relative error is at least 10 times better. Results after a year of work by Boeing and JPL indicate a gyroscope with 0.4 degree/hour error.



A two-year effort to incorporate this gyroscope into an IMU has begun, which should be complete in 2004. Any interested parties in an IMU with better than 1 degree/hour error please contact Lt Col Gregory Vansuch.

Finally, DARPA is also looking for new ideas in navigation and guidance. The MEMS INS solution, while great for the so-called tactical user satisfied by 1 degree/hour accuracy, does not solve everyone's problem. Most aircraft, ships, spacecraft, and many missiles require better accuracy, and almost any tactical user will buy as accurate a system as he can afford. As indicated by the meso-gyro effort, there is always interest in ideas to produce affordable, small, robust navigation solutions to serve higher precision DoD needs. If you have ideas on how to do this, please contact Lt Col Gregory Vansuch.



While a strong motivation for the MEMS INS is for man-portable navigation, it is clear that this is not a complete solution for the soldier. Soldiers' missions last hours or days, during which an INS will drift significantly. Integrated sensor systems are clearly required. While GPS is a wonderful sensor for the soldier, it does not work in buildings, dense foliage, or urban environments. If you have ideas for extremely small, low-powered human-based navigation approaches that are suitable for these GPS-challenged environments, please contact me.